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NATIONAL BUREAU OF STANDARDS REPORT

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A. F. Robertson
and
T. G. Lee

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

A METHOD FOR APPLICATION OF POWDERS TO TEST FIRES

ABSTRACT

A device is described which permits controlled application of dry powders to flammable liquid test fires. Measurements have been made with its use in studying the relative extinction efficiency of commercial dry chemical and potassium oxalate monohydrate. It is shown that the relative quantities of these powders required for extinguishment of 6-in. diameter n-heptane fires are quite similar to those previously found necessary for fires of about 1-in. diameter.

INTRODUCTION

A previous report, No. 5200, described measurements which were made to determine the extinction efficiency of commercial dry chemical (a treated sodium bicarbonate powder) and potassium oxalate monohydrate for the extinction of heptane fires in cups of about 1-in. diameter. It was shown that for a given powder particle size, the weight rate of application required for extinguishment was markedly less with potassium oxalate monohydrate than with sodium bicarbonate. Because of this, it seemed likely that differences in the physical chemical properties of the powders might be responsible. This possibility encouraged the hope that improvement could be made in the extinction efficiency of dry chemical extinguishers. However, it was recognized that the results obtained had been secured with the use of very small fires and it was considered likely that similar effects might not be observed with larger fires.

The work reported here was performed in an effort to secure some information on the effect of changes in fire size on the relative effectiveness of the two powders. The chief problem involved in performing this work was the development of a device which would permit controlled application of powder to the fires. The device desired must be of such a nature that: (1) the weight rate of application could be precisely controlled in a continuous fashion over a wide range, and (2) the end effects of the non-uniform portion of the discharge during starting and stopping must be short in time. The second requirement is obviously desirable to obtain a long period of uniform discharge characteristics.

APPARATUS AND PROCEDURE

After several unsuccessful attempts to construct a powder dispenser, a device was built which showed good performance. This device is shown diagramatically in Figure 1. The powder, held in container A, was fed by means of a serrated rotor B, to a short passage C. Air entering both ends of this passage was used to strip the powder from the serrations and feed it through a passageway to the nozzle D. Since the speed of the rotor could be changed, by means of a variable speed drive, it was possible to regulate the rate of flow of powder. Figure 2 illustrates the arrangement used for studying the behavior of powders projected by means of this unit. A clock-driven timer was used to control the starting and stopping of the motor and thus the discharge of powder. In order to further reduce the effects of transients during discharge of this powder, a solenoid operated powder diverter through which the powder was removed by means of a vacuum system, was used to limit the duration of powder application.

Calibration of the dispenser operation was accomplished by the use of a cellulose extraction thimble within the diverter head. This thimble provided a means for collecting the powder discharged during the time interval the diverter was positioned before the discharge nozzle. Discharge measurements were made under two different air flow conditions involving supply pressures of about 2 lb/in.^{2} and 7.5 lb/in.^{2} gage. This resulted in low and high air flow rates through the dispenser of respectively 350 c.c./sec and 750 c.c./sec prior to initiating the powder discharge process. During the discharge these air flow rates were considerably reduced. The amount of reduction depended on the rate of powder additions.

Extinguishment studies were performed with a fire of 30 ml n-heptane floated on water at room temperature contained in a 6-in. inside diameter brass container having 1/8 in. walls. This container was 4-in. high and was fitted with a horizontal flange which was 12 in. in diameter. During tests, a freeboard of 1/8 in. was maintained above the water surface and a preburn period of 45 sec was used. Powder application to the fire was limited to 1.8 sec. Calibration checks were performed immediately following each extinguishment test.

The dry powders used for study were prepared from a commercial dry powder which was separated into various particle size ranges by means of an elutriator. The potassium oxalate monohydrate powders were ground in a ball mill with 2 percent, by weight, of zinc stearate to promote free flowing behavior. These, again, were separated into various size ranges by sieving and elutriation. The particle sizes reported were determined with a Fisher Subsieve-Sizer based on air permeability principles.

RESULTS AND DISCUSSION

Figure 3 presents results obtained from calibration tests of the dispenser unit. At low speeds the powder discharge rate was found to be a linear function of rotor speed. At higher speeds the air flow rate became critical and for low air flow rates powder discharge became nearly independent of speed. At all speeds the reproducibility of the data was not as good as would have been desired. Five percent variations in discharge rate were common and at low speeds greater variations were observed. In spite of these difficulties, the dispenser was considered highly successful. Experience gained with its use encourages belief that an improved air supply system can materially improve the efficiency and thereby reduce the variations observed.

A limited number of tests have been performed to compare the application rates required for extinction of fires with both sodium bicarbonate and potassium oxalate monohydrate powders. The results are shown in Figure 4. Here the weight of powder discharge is plotted against particle size of the powder. All powder applications which resulted in extinguishment have been encircled. The unencircled data represent unsuccessful extinguishment attempts. The dashed lines have been replotted from Report 5200. In doing this, a scaling constant was used to permit plotting the two curves in approximate agreement for powder particle size of 16 microns. The difference in techniques used for powder application obviate an exact comparison of application rates. What does appear of interest is the fact that the relative quantities of the two powder types required for extinguishment seem to remain fairly independent of fire size in the range of 1- to 6-in. diameter.

It is possible that the similar behavior of the extinguishing agents on the two fire sizes provides some evidence that the burning behavior of the fires are not significantly different. This would be surprising but may be possible. The fact that the dispensing unit tested has performed so well makes it seem quite practical to build a still larger unit which can be used for full size fires outdoors.

SUMMARY

1. A dispensing device has been constructed for application of powders to fires and can be used successfully at application rates as high as 9 gm/sec.

2. During application of two different chemical powders to fires of 6-in. diameter, similar differences in application rates were observed as had been previously obtained for much smaller fires.

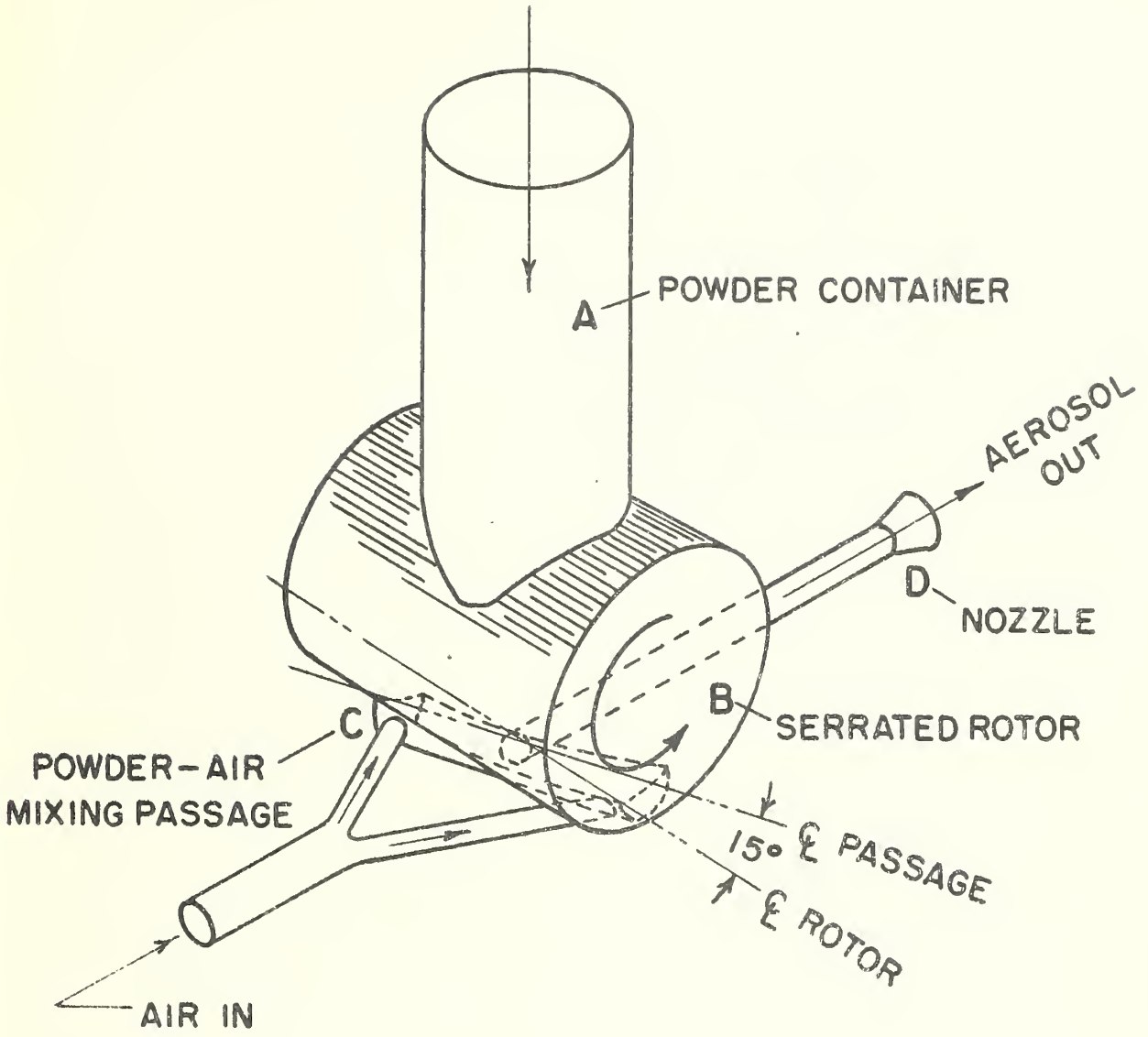

FIG. 1 - DIAGRAMMATIC VIEW OF DISPENSER CONSTRUCTION

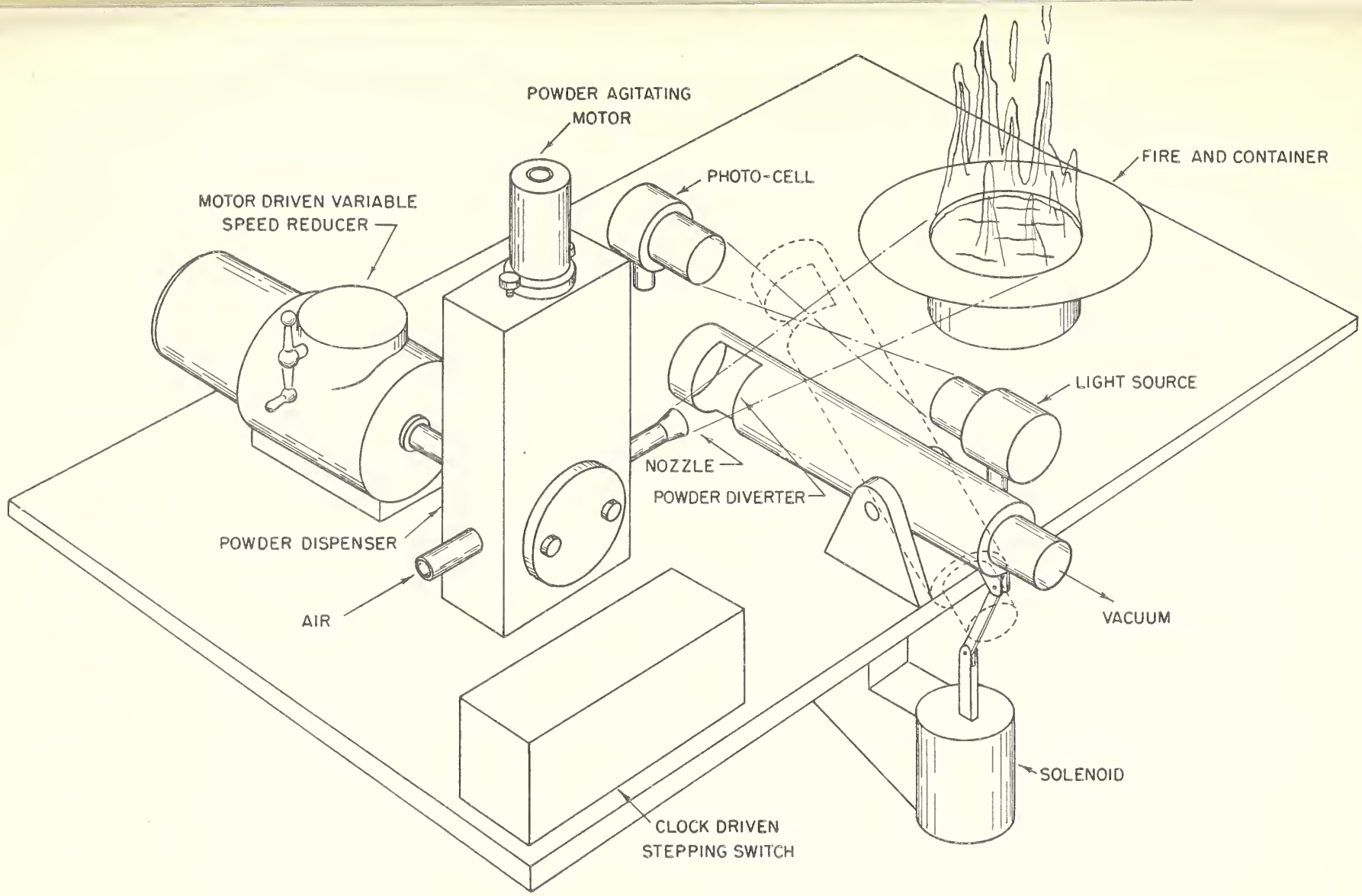

FIG. 2 - GENERAL ARRANGEMENT FOR EXTINGUISHMENT TESTS

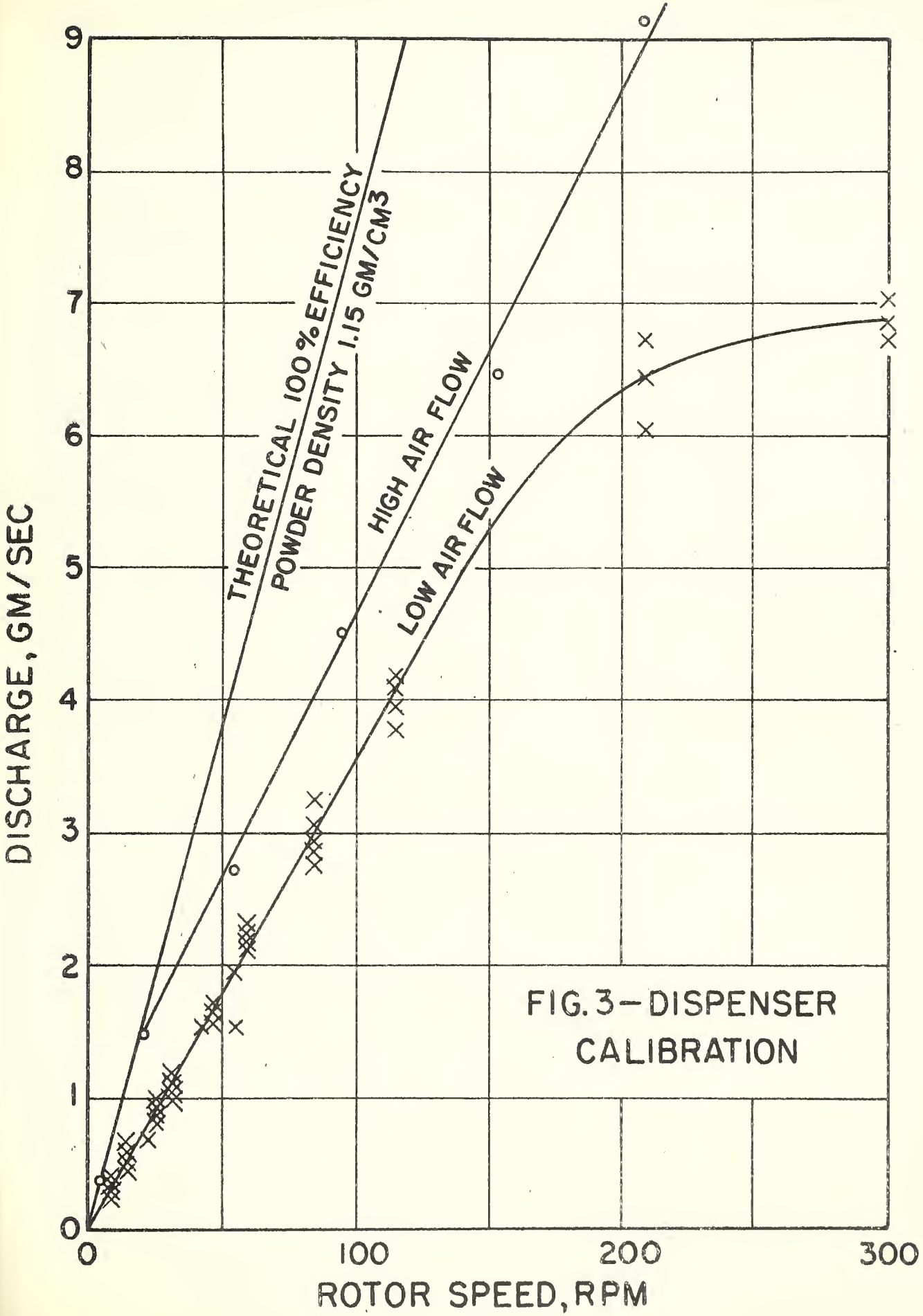

FIG. 3 – DISPENSER CALIBRATION

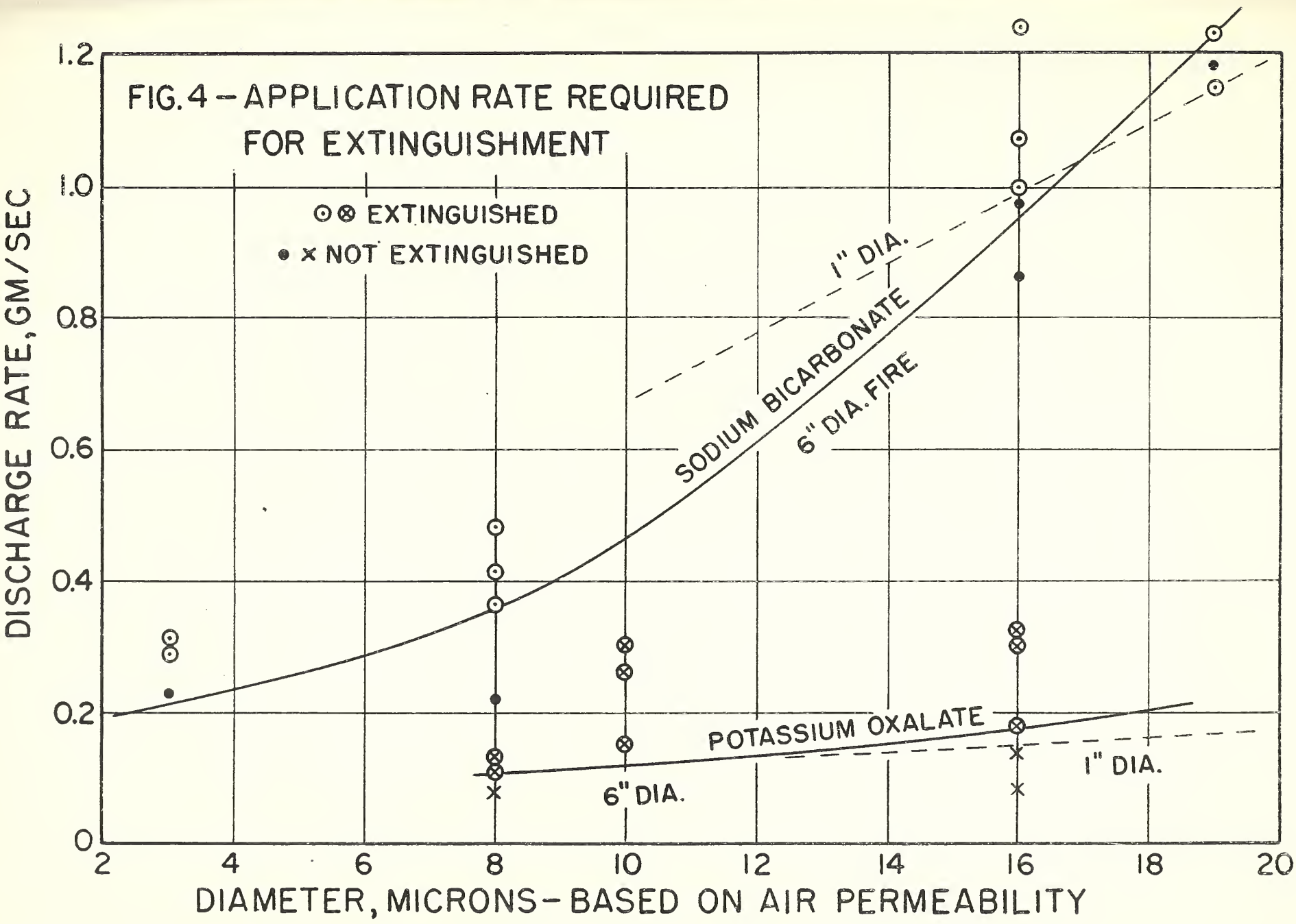
FIG. 4 – APPLICATION RATE REQUIRED FOR EXTINGUISHMENT
⊙⊗ EXTINGUISHED
• × NOT EXTINGUISHED
1" DIA.
SODIUM BICARBONATE
6" DIA. FIRE
POTASSIUM OXALATE
1" DIA.
6" DIA.
DISCHARGE RATE, GM/SEC
DIAMETER, MICRONS – BASED ON AIR PERMEABILITY
0
0.2
0.4
0.6
0.8
1.0
1.2
2
4
6
8
10
12
14
16
18
20

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